Space and Missile Systems Center
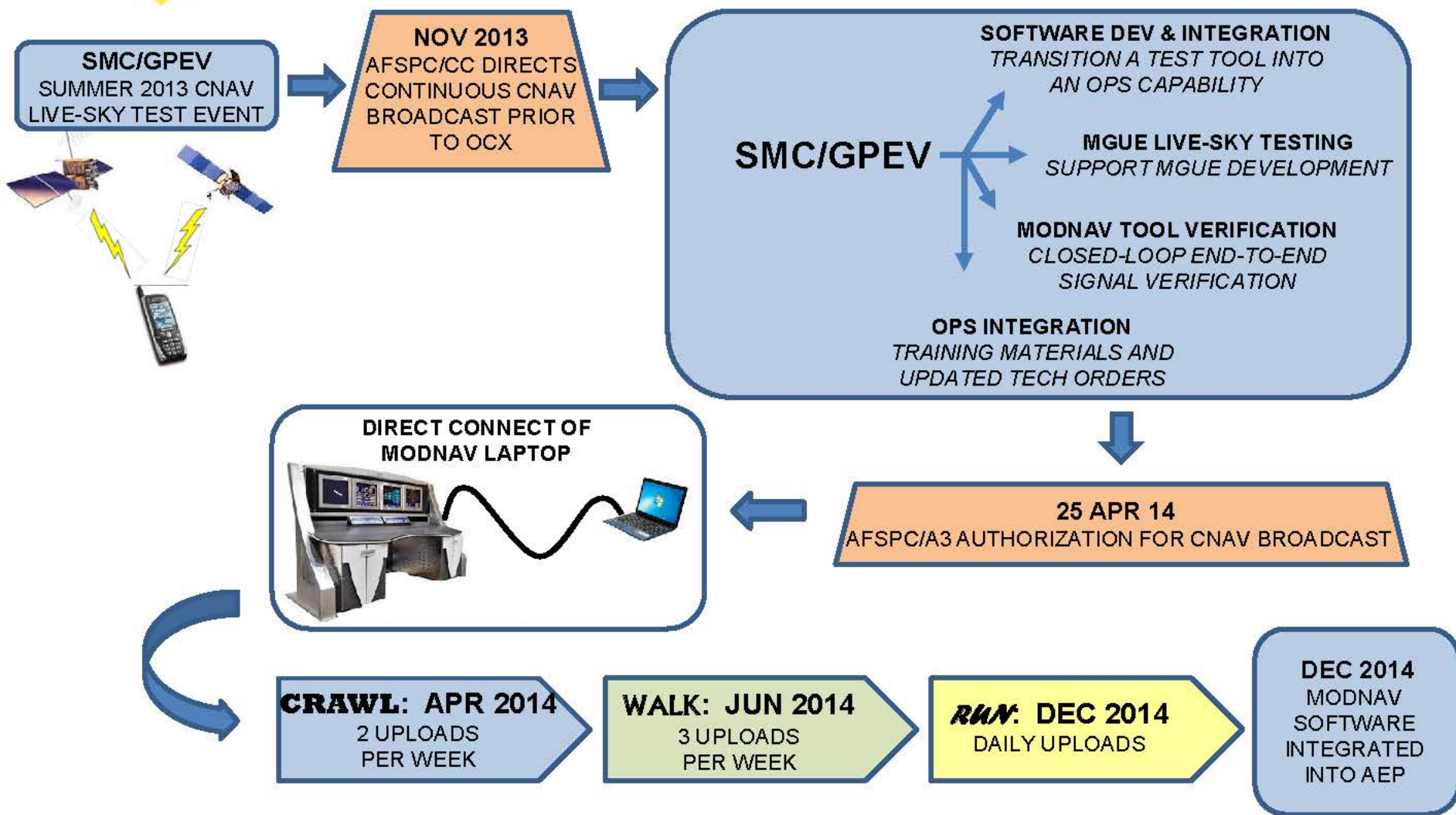
Civil Navigation
Signal Status

Maj Michael Zollars

29 Apr 15

Report Documentation Page		*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE **29 APR 2015**	2. REPORT TYPE	3. DATES COVERED **00-00-2015 to 00-00-2015**
4. TITLE AND SUBTITLE **Civil Navigation Signal Status**		5a. CONTRACT NUMBER
		5b. GRANT NUMBER
		5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER
		5e. TASK NUMBER
		5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Air Force Space Command,Space and Missile Systems Center,Los Angeles AFB,El Segundo,CA,90245**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES **Presented at the GPS Partnership Council 2015 (GPSPC15), held April 29 to May 1, 2015, at the Los Angeles AFB, CA.**		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a REPORT **unclassified**	b ABSTRACT **unclassified**	c THIS PAGE **unclassified**	**Same as Report (SAR)**	**9**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

Civil Navigation(CNAV) History

SPACE AND MISSILE SYSTEMS CENTER

SMC/GPEV
SUMMER 2013 CNAV
LIVE-SKY TEST EVENT

NOV 2013
AFSPC/CC DIRECTS
CONTINUOUS CNAV
BROADCAST PRIOR
TO OCX

SMC/GPEV

SOFTWARE DEV & INTEGRATION
*TRANSITION A TEST TOOL INTO
AN OPS CAPABILITY*

MGUE LIVE-SKY TESTING
SUPPORT MGUE DEVELOPMENT

MODNAV TOOL VERIFICATION
*CLOSED-LOOP END-TO-END
SIGNAL VERIFICATION*

OPS INTEGRATION
*TRAINING MATERIALS AND
UPDATED TECH ORDERS*

**DIRECT CONNECT OF
MODNAV LAPTOP**

25 APR 14
AFSPC/A3 AUTHORIZATION FOR CNAV BROADCAST

CRAWL: APR 2014
2 UPLOADS
PER WEEK

WALK: JUN 2014
3 UPLOADS
PER WEEK

RUN: DEC 2014
DAILY UPLOADS

DEC 2014
MODNAV
SOFTWARE
INTEGRATED
INTO AEP

Civil Navigation(CNAV) Broadcast Status

SPACE AND MISSILE SYSTEMS CENTER

- CNAV Message Types 10, 11, 30, 33 currently transmitted on seven GPS IIR-M (L2C) & eight GPS IIF SVs (L2C & L5)
  - MODNAV Tool integrated w/AEP providing CNAV message generation
  - Daily CNAV uploads as of 31 Dec 14
- Signal Performance
  - CNAV performing on par with Legacy during daily uploads
  - Total RMS URE from 31 Mar – 7 Apr 15
    - Legacy: 0.517 m (URE for this week aided by additional LNAV uploads)
    - Modernized: 0.584 m
  - Best week: 22 Mar - 29 Mar 15
    - Modernized: 0.397 m
- GPS IIF Launch & Constellation Upgrade
  - SVN 68 & SVN 69 Ops Accepted to users for Legacy Signals
    - CNAV message broadcast as of 23 Feb 15
  - SVN 71 successful launch 25 Mar 15
  - SVN 72 Launch scheduled for Jul 2015
    - CNAV message broadcast for SVN 71 & SVN 72 expected Aug 2015

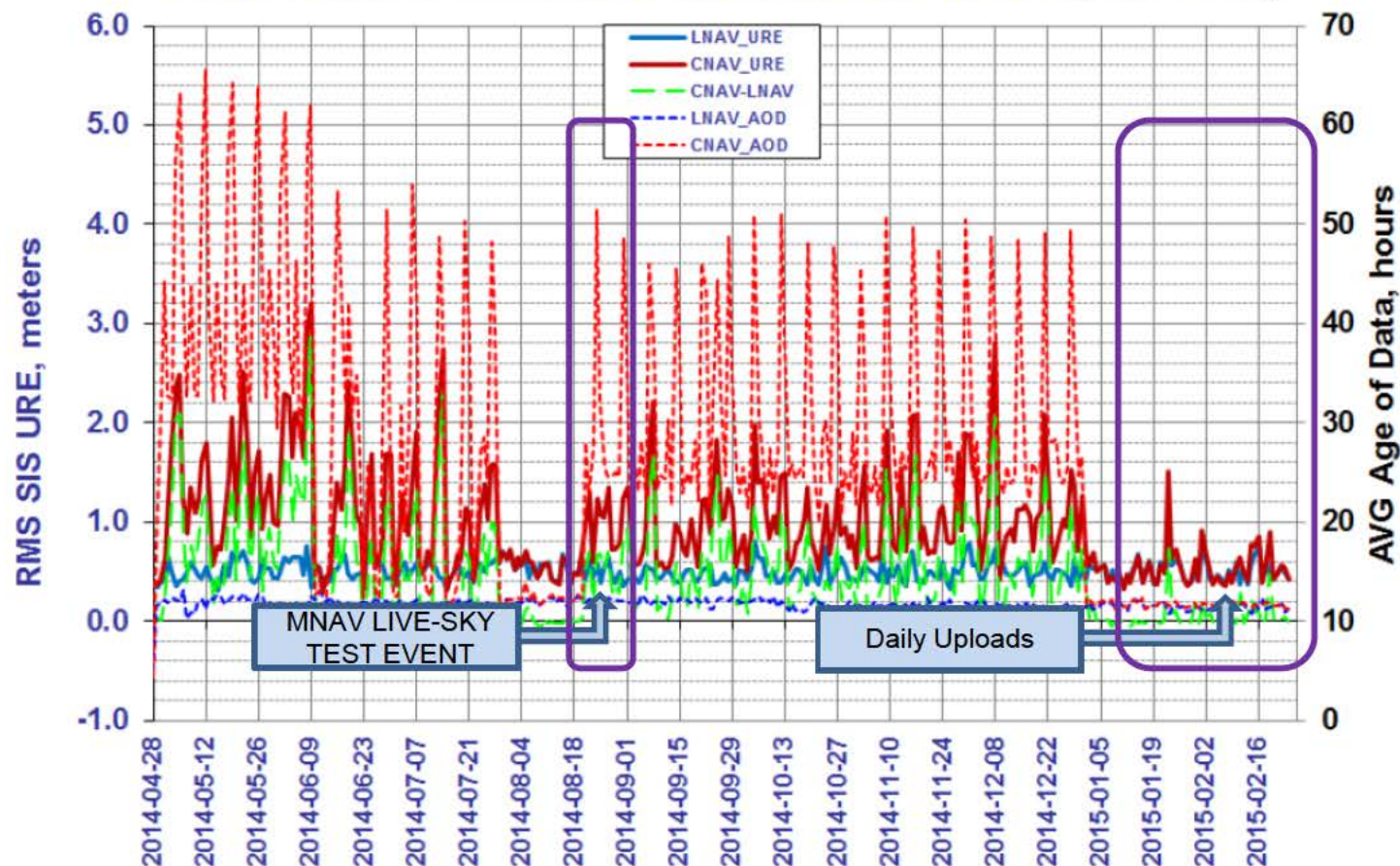**Pre-operational CNAV Broadcast Performance As Expected**

CNAV Performance

S P A C E   A N D   M I S S I L E   S Y S T E M S   C E N T E R

L2C Performance: 28 Apr to 28 Feb 14

CNAV & LNAV Performance from Modernized SVs (IIRM & IIF)
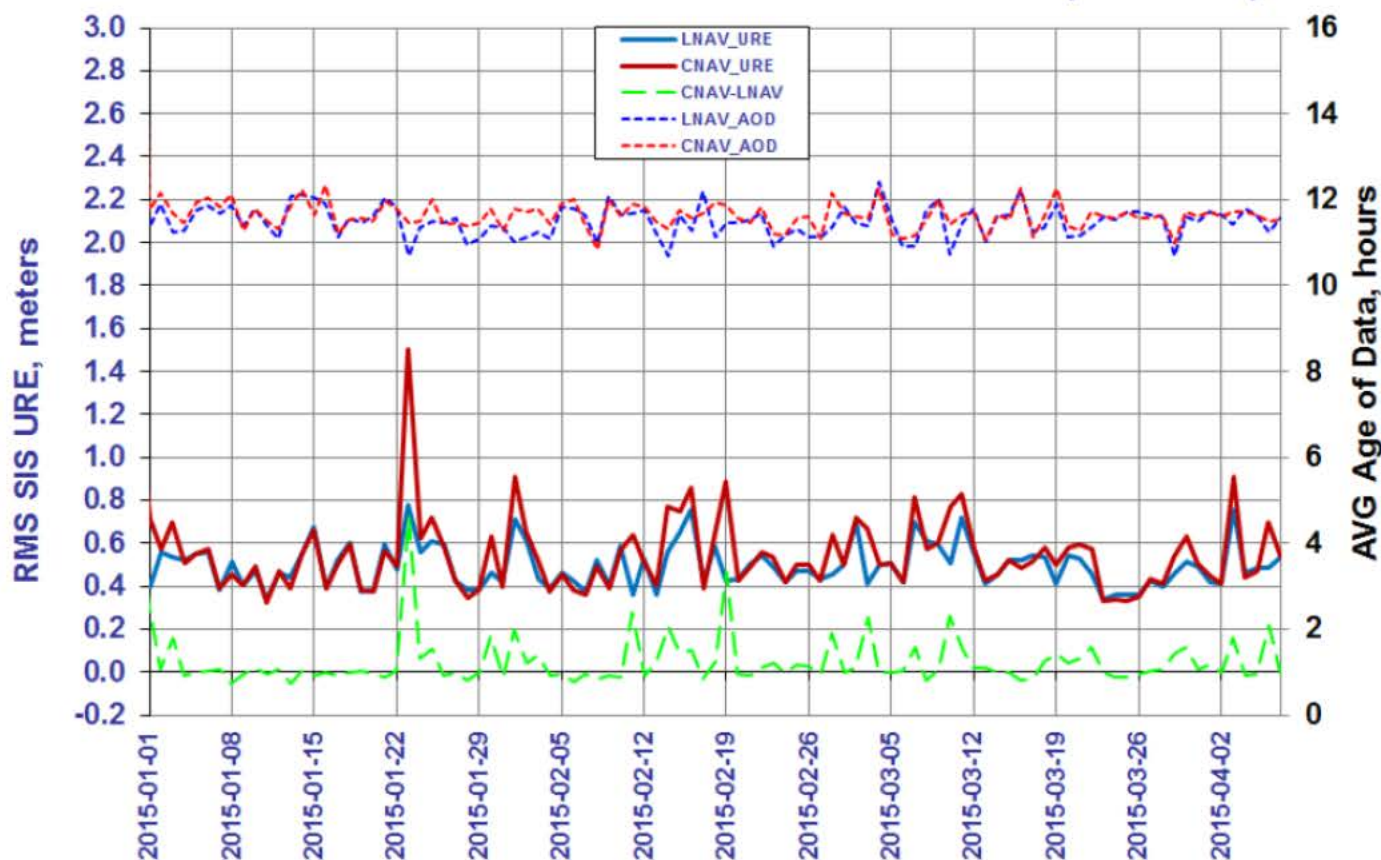
MNAV LIVE-SKY TEST EVENT

Daily Uploads

Daily uploads of pre-operational CNAV performance within expectations

CNAV Performance

SPACE AND MISSILE SYSTEMS CENTER

– **L2C Performance starting with Daily Uploads: 1 Jan 15 to Present day**

CNAV & LNAV Performance from Modernized SVs (IIRM & IIF)

LNAV slightly better than CNAV due to addition LNAV uploads

CNAV Development

SPACE AND MISSILE SYSTEMS CENTER

- Live-sky event summer of 2013
  - Test & Verification of 8/15 defined CNAV Message Types
  - Led to pre-operational use beginning 28 Apr 14
- Planned live-sky event fall of 2015
  - Incorporate Midi Almanac (MT37)
    - GPS IIF SV require only MODNAV Tool software updates
    - GPS IIR-M SVs require MODNAV Tool & SV software updates as well as changes to ICDs
  - Exercise functionality of GNSS off-set parameters (MT35)
    - Integration efforts in progress with NGA and USNO for direct feed of GGTO, UTC and ISC values into AEP
- Future development TBD
  - Software development and test of differential corrections & text messaging require additional knowledge on CONOPs and/or intended use
    - MT13 (Clock Differential)
    - MT14 (Ephemeris Differential)
    - MT15 (Text)
    - MT34 (Clock & Differential)
    - MT36 (Clock & Text)
  - Broadcast of reduced almanac (MT 12 & MT 31) is unlikely; pending further direction

CNAV Development

SPACE AND MISSILE SYSTEMS CENTER

Msg Type	CNAV Message Title	Function/Purpose
0	Default	Default message (transmitted when no msg data is available)
10	Ephemeris 1	SV position parameters for the transmitting SV
11	Ephemeris 2	SV position parameters for the transmitting SV
12	Reduced Almanac	Reduced almanac data packets for 7 SVs
13	Clock Differential Correction	SV Clock differential correction parameters
14	Ephemeris Differential Correction	SV Ephemeris differential correction parameters
15	Text	Text, 29 eight-bit ASCII characters
30	Clock, IONO & Group Delay	SV Clock Correction Parameters, Ionospheric and Group Delay correction parameters (Inter-Signal Correction parameters)
31	Clock & Reduced Almanac	SV Clock Correction Parameters, Reduced almanac data packets for 4 SVs
32	Clock & EOP	SV Clock Correction Parameters, earth orientation parameters; ECEF-to-ECI coordinate transformation
33	Clock & UTC	SV Clock Correction Parameters, Coordinated Universal Time (UTC) Parameters
34	Clock & Differential Correction	SV Clock Correction Parameters, SV clock and Ephemeris differential correction parameters
35	Clock & GGTO	SV Clock Correction Parameters, GPS to GNSS Time Offset parameters.
36	Clock & Text	SV Clock Correction Parameters, Text, 18 eight-bit ASCII characters
37	Clock & Midi Almanac	SV Clock Correction Parameters, Midi Almanac parameters

15 Defined Message Types

- Tested & verified summer of 2013
- Development planned for fall test event 2015
- Conops/direction required for development & test

CNAV Monitoring

SPACE AND MISSILE SYSTEMS CENTER

- Operational monitoring of civil modernized signals
  - Joint Propulsion Lab (JPL) world-wide monitoring stations
    - Initial capability and procedures delivered to 2SOPS Dec 2014
    - Capability upgrade scheduled for Feb 2016
- SMC/GP MODNAV Database & Website
  - SMC/GP & MITRE CONUS CNAV website data bits (L2C & L5) updated every 15 min or less @ https://gps-modnavdb.mitre.org
  - NGA global CNAV data bits (L2C only) updated daily
  - Expansion of NGA L5 Signal Monitoring by 3Q 2015
    - L2C and L5 updated every 15 min or less
- Legacy signals remain the priority during CNAV pre-operational broadcast
  - If URE or AOD limits are exceeded, the path forward will not affect the broadcast of legacy signals
  - Collaboration with GPE, GPL and FFRDC teams to include the GPE/MITRE MODNAV database & website will occur to determine the best course of action if the URE or AOD limits are exceeded

Questions

SPACE AND MISSILE SYSTEMS CENTER